REAL-TIME HOME AUTOMATION AND MONITORING SYSTEM WITH TASK SCHEDULING AND INTERNET CONNECTIVITY

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ABSTRACT

This paper presents a low cost and flexible home control and real-time home monitoring system using FRIENDLY ARM processor that can be programmed and controlled remotely with IP connectivity for accessing and controlling devices and appliances remotely using any device with internet connectivity. The proposed system does not require a dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment in real-time with more than just the switching functionality. Any device that has access to internet can be used to control the system. A HTML page is dedicatedly designed for this purpose where in we can both control as well as monitor the system. To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor and current sensor have been integrated with the proposed home control system. Scalability is one major advantage of this system wherein we can just add multiple devices to the automation circle without much complexity of hardware and software. Also both I2C and SPI protocols have been analyzed and implemented in this system to check for better efficient working of the system.

Keywords: home monitoring system, automation, internet connectivity.

1. INTRODUCTION

Home automation, can be many different things and it can be applied at different levels. It might range from a simple control remote to turn on/off different switches such as lights to complex sequences of actions that might define different environments in the living room of our house. Imagine a remote control with a set of buttons to change the look of your living room. If you want to enjoy the latest movie with your family or friends you press the theatre button and the living room turns into a theatre: main lights come off while the LED lighting around the room comes on and the blinders lower down; a screen rolls down, the thermostat sets the temperature to the perfect environment while the projector at the back of the room starts the movie. Imagine at the end of the movie you want to have dinner with your family or friends in the other side of the living room, so you press the dinner button to turn the living room into a dinner room: the lights on top of the dinner table come on while the LED lights come off, the screen rolls up, etc. This is just one example of the hundreds of systems that can be installed, programmed and managed. However, different users would like different configurations for a theatre environment and therefore the sys-tem needs to be very flexible and easy to reconfigure, in order to be adapted for each user demands. A few examples of features that can be included in the home automation system are given below:

▪   **Lighting:** Lighting systems can be programmed to switch off in certain lighting conditions (natural light is adequate), reducing lighting costs. Alternatively, lights can be set to switch on automatically when one person enters a room, making the home safer and also reducing power consumption. In addition, lighting can be set to create different environments as mentioned before.

▪   **Intelligent climate control:** Heating and air conditioning can be set to certain levels based on different parameters, such as expected and actual occupancy, the weather forecast, the inside temperature or, if a window or exterior door is left open. These systems can also be controlled remotely. This is a great savings mechanism, reducing the amount of electricity wasted on unnecessary cooling or heating, ensures at the same time that the house is at the right temperature at all times.

▪   **Security systems:** Security systems can also be automated and integrated with other house devices. Systems respond to voice and biometric data, and locks can be upgraded to keypads that are opened with codes or swipe cards. These systems can also be turned on or off remotely. Besides, while we are on vacation we can see images of the cameras, receive messages from our house and activate alarms if necessary.

▪   **Home entertainment:** Automated home entertainment systems allow the users to preset favourite settings, remove the need for multiple remotes and listen to music, news, or podcasts anywhere in the house. Most systems can be tailored by a custom electronics professional to provide all the benefits desired by the users. However, there are some key features that will make the programmer's job easier and the interaction with the home automation system more enjoyable. The main features are:

▪   **Interoperability:** All the diverse electronic devices must be integrated and centralized, so they can

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perform as one unified system. In order to be able to connect all the different devices, the central control system has to be open and able to communicate with all the sensors and actuators. Even though some standards have been adopted, special care has to be taken when buying new devices in order to be able to interact with the home automation system.

▪   **Remote access:** Being able to communicate remotely with the home automation system is one of the most celebrated features. Remote access capabilities allow the home owner to monitor the home's environment and also alter the settings of the lights, thermostats and other gear if necessary all, from a laptop, personal computer, cellphone or any mobile device.

▪   **Scalability:** Technology will continue to evolve, introducing new generations of products to the marketplace. Ability to expand the system to multiple devices is being implemented.

▪   **Flexibility:** Automation is only beneficial and practical if it fits the home owner's lifestyle. Since everyone's lifestyle is different, the manufacturer should provide its installers with the tools to customize the system to user's specific needs. This goes both for the installer and the manufacturer. The manufacturer should provide flexible programming tools for the installer to design and adapt each automation system to the user's needs.

▪   **Robustness:** The system should be able to deal with the most common problems such as when the power on the house goes down. For this case, the automation system should have the appropriate back-up protection.

▪   **Power Saving:** Automation systems can help save energy by turning off electronics devices automatically.

Most of them are functional only for sub-products within the brand that sells the system as a whole, but some are compatible. One of the most popular computer open source software for general Home Automation applications is MisterHouse, which is customizable, very flexible and compatible with most technologies. However, it is very geeky and some programming knowledge is needed to manage it and it has to be written in Perl. The popular Internet of Things or IOT can be seen as a way of saying that devices in the home are connected via the Internet. Most of these devices connect directly to each other or through the router. However, other devices might connect to the cloud (some corporate server on the web).
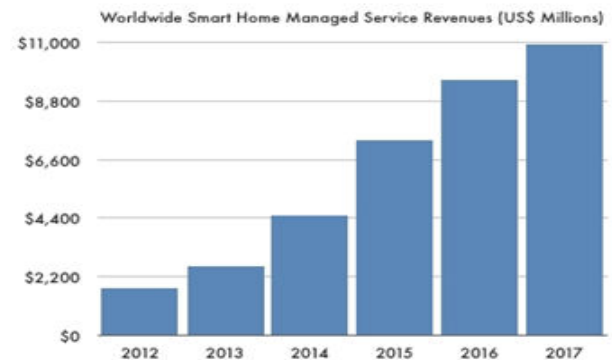

Figure-1. Chart showing home automation industry growth.

As shown in the graph above the Home Automation industry is growing exponentially at a very fast pace. With the advancement in technology people like to make everything around them automated so they can live peacefully. More than anything nowadays home automation has become a luxury statement too. That said automation makes our life much more efficient and it also conserves the nature by reducing the energy consumption. It gives us a feeling that we have a complete control over all the devices that we use in our day to day lives. The benefit of IOT devices in the home is that they allow you to control and monitor your home system from anywhere through your iPhone or any other mobile device or computer connected to the internet.

2. OVERVIEW

The main aim of this project is not to implement a complete home automation system but to rather find a better and efficient technology with much better features. At every point in the design and development of the system this was made sure to be followed. We tried using minimal hardware that is very much effective to control the system in a robust manner. Protocols such as I2C and SPI were studied and were implemented in the system to see how these different protocols make the communication between the devices easier and efficient. One other important factor that I tried to implement in this project is scalability and compatibility which is a major concern in today's home automation market. The home automation systems present in the current market doesn't have this feature to include devices from different brands into the system. Also there is a limit on the number of devices that can be included in the system and all of this comes at a steep price for the consumers.
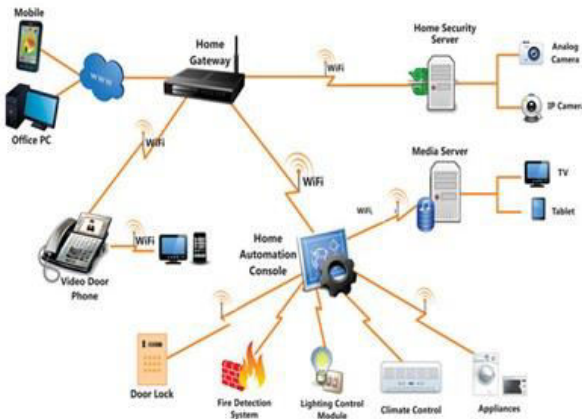
Figure-2. Proposed home automation system.

Flexibility is also a key concern as the usage pattern differs with respect to different person. So I have tried to make the user interface as simple and accessible as possible by creating a web page using HTML that can be accessed on any device that can access the internet. Much thinking and research has gone in the selection of the required hardware keeping the cost factor in mind. Let's take a detailed look at the hardware we have used in this system.

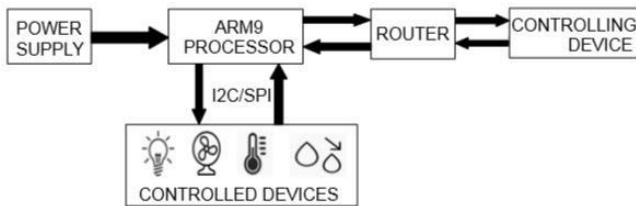The diagram below shows the block diagram of the proposed home automation system.

Figure-3. Proposed home automation system block diagram.

When it comes to home automation there is a lot of scope in terms of technology and innovation. Devices can be connected wireless under one single protocol and can be accessed from anywhere with much ease and security. Every single device can be brought right under our eyes regarding its performance and its energy usage.

The mini2440 is a practical low-cost ARM9 Single Board Computer (SBC) with a very high performance/cost ratio. With the Samsung S3C2440 microprocessor and the use of professional layout and quality peripheral chips, it is very robust. The Mini2440 uses a four-layer board design with gold immersion processing, and has high quality equal-length bus routing in timing critical areas. The production environment and quality control are the same as those of modern high-speed motherboards.

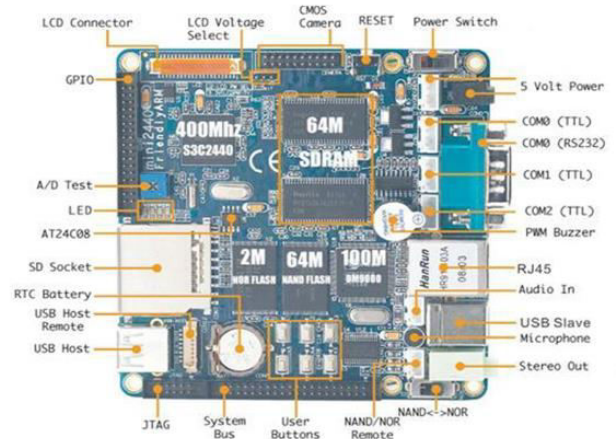The next diagram shows the ARM9 board with its components.

Figure-4. MINI2440 component side.

The S3C2440A (450 MHz) offers outstanding features with its CPU core, a 16/32-bit ARM920T RISC processor designed by Advanced RISC machine ltd. The ARM920T implements MMU, AMBA BUS, and Harvard cache architecture with separate 16KB instruction and 16KB data caches, each with an 8 –word line length. The S3C2440A minimizes overall system costs and eliminates the need to configure additional components Final Stage

3. DEVELOPMENT

Coding and development for the home automation system was done under the linux platform using a GCC computer. To access the devices interfaced to the system we used CGI (Common Gateway Interface) shell scripting.
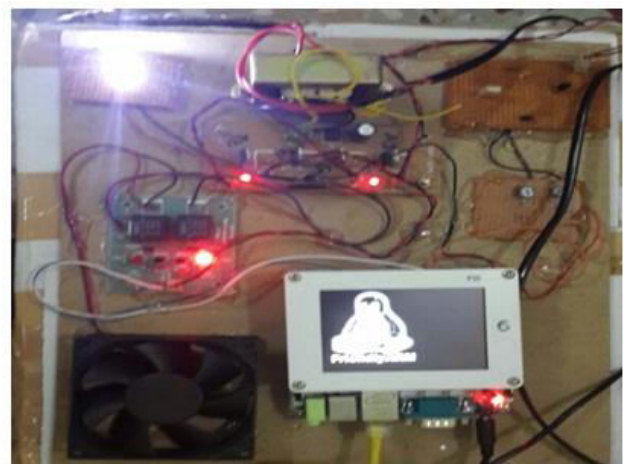

Figure-5. System boot up sequence.

Figure above shows the complete home automation system model. The figure shows the system under boot up sequence.
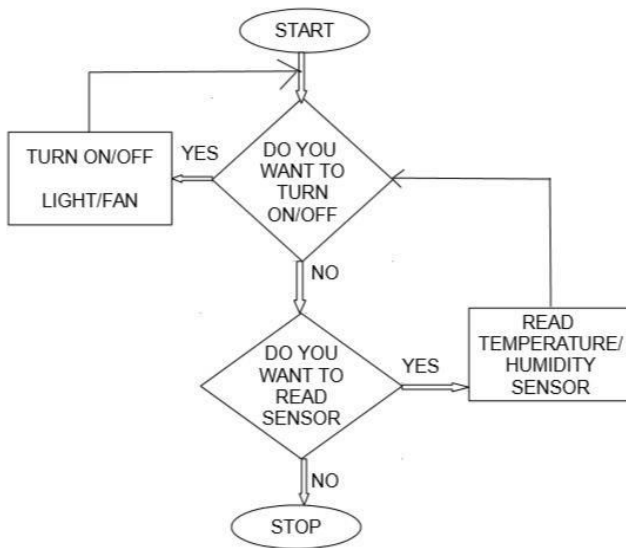
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Figure-6. Flowchart for home automation system.

The diagram above gives a clear view of how the home automation system is going to be implemented. It breaks down the problem to its simpler self.

As we discussed earlier the main aim of the project is to study and implement the technology in the system. By sticking to it we have connected and programmed fewer devices to be able to control and monitor them to check if the system works with the implemented design.

a) CGI Script

Unlike PHP scripts, which are in users' normal public_html directories, CGI programs are normally put in a special directory called something like /cgi-bin. Everything in this directory is treated by the server as a program to be run, not a file to be displayed.

The script will go in something like:

```
/htdocs/cgi-bin/USER/prog
/cgi-bin/USER/prog
(recall /htdocs)
```

Your path for where to put the script may vary. The input comes in as the environment variable QUERY_STRING. If there is a single argument, QUERY_STRING will be of the form:

```
fieldname=actualargument
```

So it is needed to edit it to remove the fieldname= bit at the front. The CGI script builds a web page dynamically, by outputting HTML tags to stdout. The CGI script can be written in any language. I'll be writing it here in UNIX Shell.

b) HTML code

In order to control and monitor the devices from any device with an internet connection; the system is connected to a router connected to the internet. An HTML page is created with control buttons using which can control the devices connected to the home automation network.

Security comes before everything else, so a secure login page is created so that only intended user can access, control and monitor the automation network. Only when the right credentials are entered will the user be provided with the control and only then they can access the automation network.

Figure-7. Configuring of I/O ports.

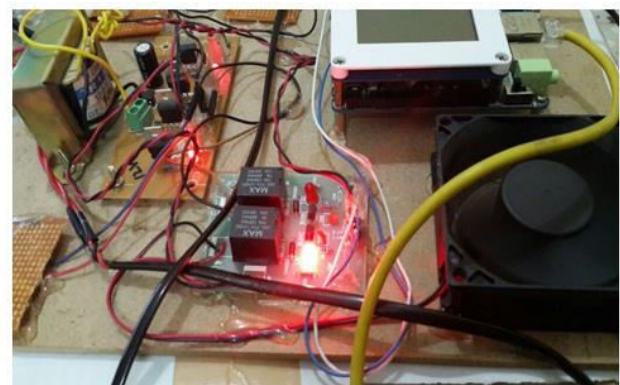**4. RESULTS AND DISCUSSIONS**

Figure-8.

5. CONCLUSIONS

The main aim of this project is to study the technology to implement a low cost home automation system that is less complex and more efficient. Though it

is a complex task i tried to achieve it as close as possible. Proper hardware and compatible software was chosen after doing much research into it. I2C and SPI protocols were studied and implemented in the project to see which protocols proves to be much more efficient for the automation system. I2C is a multi master multi slave protocol and it is easier to communicate with various devices and it is more efficient but is more complex when it comes to implementing it. Whereas SPI protocol is a single master multi slave protocol and it is very easy to implement but the communication between devices takes a long time compared to I2C.

The ARM9 processor is programmed to communicate with various sensors and also respond to various user controls. All devices are continuously monitored for any abnormalities and are activated once the user issues a turn ON or turn OFF request. One of the most important feature of this home automation network is that if we want to add any new device to the automation network in future we can just simply add the device without any complex configuration or much hardware.

To control the devices the user is provided with a unique login credential using which he access the control page wherein there are buttons to control and monitor each device that is connected to the network. To be able to control and monitor the home automation system from any place in the world the ARM9 module is connected to the internet through a router. So now a user can access the system from any device that has access to the internet.

6. FUTURE WORK

To improve the server access security through which the user controls the system, so that any unauthorized user cannot access and control the system.

To maintain a database that logs the usage statistics of each device that is connected to the system, so that we can organize and create a monthly or yearly report of the usage statistics, which will improve the energy efficiency over a period of time.

To make all devices to be connected wirelessly and also to further improve the cost and efficiency of the home automation system.

To make the usage statistics and logs to be available to other devices. To make the devices talk to each other.

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